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Historical background

1.1 Introduction

Fermentation is one of the oldest methods practised by human beings for the transformation of milk into products with an extended shelf life. The exact origin(s) of the making of fermented milks is difficult to establish, but it could date from some 10–15000 years ago as the way of life of human beings changed from being food gatherer to food producer (Pederson, 1979). This change also included the domestication of animals (i.e. cow, sheep, goat, buffalo and camel), and it is most likely that the transition occurred at different times in different parts of the world. Archaeological evidence shows that some civilisations (e.g. the Sumarians and Babylonians in Mesopotamia, the Pharoos in north-east Africa and the Indians in Asia) were well advanced in agricultural and husbandry methods, and in the production of fermented milks such as yoghurt.

Although there are no records available regarding the origin of yoghurt, the belief in its beneficial influence on human health and nutrition has existed in many civilisations over a long period of time. According to Persian tradition, Abraham owed his fecundity and longevity to yoghurt and, in more recent times, Emperor Francis I of France was said to have been cured of a debilitating illness by consuming yoghurt made from goat's milk (Rosell, 1932).

It is likely, however, that the origin of yoghurt was the Middle East, and the evolution of this fermented product through the ages can be attributed to the culinary skills of the nomadic people living in that part of the world. Today, fermented milk products are manufactured in many countries (Campbell-Platt, 1987; Kurmann *et al.*, 1992), although few are of commercial significance.

1.2 Evolution of the process

The production of milk in the Middle East has always been seasonal, being restricted usually to no more than a few months of the year. The main reason for this limited

availability of milk is that intensive animal production has never really existed, so that, as in early history, farming is in the hands of nomadic peoples who move from one area to another following the pastures. This type of existence forces nomads to be in the wilderness for months at a time, far away from populated cities and villages where they could sell their animal produce. Another major factor is that the Middle East has a subtropical climate and summer temperatures can reach as high as 40°C. In such a climate, milk turns sour and coagulates within a short time of milking, particularly as the milk is produced under primitive conditions. Thus, the animals are hand milked, no cooling of the milk is possible, and the risk of contamination by micro-organisms from the air, the animal, the feeding stuff or the hands of the milker is extremely high. Under these conditions the possibility of transporting or even keeping milk for any length of time is non-existent. As a result the bulk of the population consume milk only rarely, and even the nomadic people have to utilise the milk virtually as it is produced.

However, it may well have been evident even at an early stage that the souring of milk was by no means a uniform process. Thus, the fermentation brought about by non-lactic acid bacteria gives rise to a product which is insipid and stale and,

Table 1.1 Selection of yoghurt and yoghurt-like products that have been identified in the Middle East and elsewhere

Traditional name	Country
Jugurt/eyran/ayran	Turkey
Busa	Turkestan
Kissel mleka/naja/yaourt	Balkans
Urgotnic	Balkan mountains
Leban/labani or laban rayeb	Lebanon and some Arab countries
Zabady/zabade	Egypt and Sudan
Mast/dough/doogh	Iran and Afghanistan
Roba/rob	Iraq
Dahi/dadhi/dahee	India
Mazun/matsoon, matsun, matsoni, madzoon	Armenia
Katyk	Transcaucasia
Yiaourti	Greece
Cieddu	Italy
Mezzoradu	Sicily
Gioddu	Sardinia
Tarho/taho	Hungary
Viili	Finland
Filmjolk/fillbunke/filbunk/surmelk/taettemjolk/tettemelk	Scandinavia
Iogurte	Brazil and Portugal
Skyr	Iceland
Gruzovina	Yugoslavia
Donskaya/varenets/kurugna/ryzhenka/guslyanka	Russia
Tarag	Mongolia
Shosim/sho/thara	Nepal
Yoghurt/yogurt/yaort/youurt/yaourti/ yahourth/yogur/yaghourt	Rest of the world ("Y" is replaced by "J" in some cases)

After: Tamime and Deeth (1980), Accolas *et al.* (1978), Tokita *et al.* (1982) and Kosikowski and Mistry (1997).

furthermore, the coagulum is irregular, filled with gas holes and shows extreme whey syneresis. Lactic acid bacteria, however, act on milk to produce a fermented product which is pleasant to eat or drink; this latter product was usually referred to as sour milk.

The animals that are raised by the nomadic peoples of the Middle East are cows, goats, sheep and camels, and gradually the nomadic tribes evolved a fermentation process which brought under control the souring of these various milks. In particular, the process might have included:

- use of the same vessels, or the addition of fresh milk to an on-going fermentation, relying mainly on the indigenous microflora to sour the milk;
- heating the milk over an open fire to concentrate the milk slightly, so that the final coagulum would acquire an attractive viscosity due to the modified properties of the casein, again a change which would have improved the quality of the end product;
- seeding the heat-treated and cooled milk (blood or ambient temperature) with sour milk from a previous batch, so enabling the thermophilic strains of lactic acid bacteria to become predominant;
- gradual selection of lactic acid bacteria capable of tolerating high levels of lactic acid and of giving the product its distinctive flavour;
- eradication of any pathogenic micro-organisms present in the milk.

Although the evolution of the process was strictly intuitive, the production of sour milk soon became the established pattern of preservation, and since the early 1900s, defined micro-organisms have been used to prepare these products on a large scale in factories. Gradually other communities learnt of this simple preservative treatment for milk and one such product became known as yoghurt from the Turkish word “jugurt”; numerous variants of this word have appeared over the years and a selection of alternatives is shown in Table 1.1.

1.3 Diversity of fermented milks

Around 400 generic names are applied to the traditional and industrialised fermented milk products manufactured throughout the world (Kurmann *et al.*, 1992). Although these products may have different names, they are practically the same, and a more accurate list might include only a few varieties. Taking into account the type of milk used, the microbial species which dominate(s) the flora and their principal metabolic products, Robinson and Tamime (1990) proposed a scheme of classification for fermented milks which divided them into three broad categories: (a) lactic fermentations, (b) yeast–lactic fermentations and (c) mould–lactic fermentations (Fig. 1.1). Recently, these products have been extensively reviewed by Tamime and Marshall (1997).

Although yoghurt has many desirable properties, it is still prone to deterioration, especially at ambient temperature, within a matter of days, and one discernible trend in the Middle East has been the search for simple techniques to extend the keeping quality.

The first step in this process turned out to be relatively simple because the containers traditionally used by the nomads for the production of yoghurt were made from animal skins. In normal use the yoghurt would have been consumed fairly

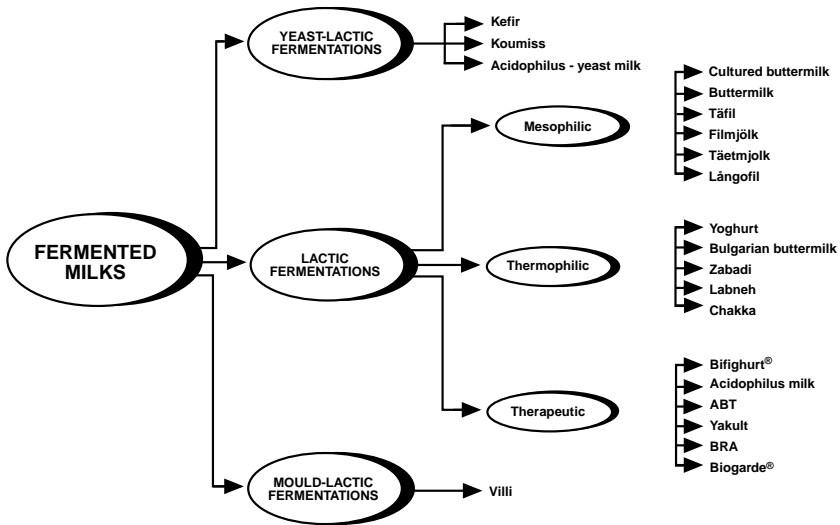


Fig. 1.1 Scheme of classification of fermented milk products (for details see Table 5.15)
 ABT, *Lactobacillus acidophilus*, *Bifidobacterium bifidum* and *Streptococcus thermophilus*;
 BRA, *Bifidobacterium infantis*, *Lactobacillus reuteri* and *L. acidophilus*. Adapted from
 Robinson and Tamime (1990)

rapidly but, if left hanging in the skin for any length of time, the nature of the product altered dramatically. Thus, as the whey seeped through the skin and evaporated, the total solids content of the yoghurt rose and with it the acidity. The end result was a condensed or concentrated yoghurt with an acidity of $>2.0\%$ lactic acid and a total solids content in the region of $25\text{ g }100\text{ g}^{-1}$; the original yoghurt might have had a solids content of $12\text{--}13\text{ g }100\text{ g}^{-1}$ and an acidity of around 1.5% lactic acid. To the nomadic people, whose main sources of wealth and nourishment are the animals that can be raised and the milk that they produce, the relative resistance of the condensed yoghurt to spoilage must have appeared attractive.

Evidence of this trend can be found in Armenia where the mazun (Armenian yoghurt) is usually pressed to yield a product called tan or than. Similarly, surplus milk production in remote villages in Turkey is turned into concentrated yoghurt by the daily addition of milk to yoghurt hanging in goat or sheep skins. Another method of concentration of yoghurt is where the product is placed in an earthenware vessel; the Egyptians call this product leben zeer.

Nevertheless, even condensed yoghurt becomes unpalatable within a week or two, and it was for this reason that salted yoghurt rapidly became popular. Salting is an age-old method used by humans to preserve food, but the incorporation of salt into concentrated yoghurt also acts as a neutralising agent to reduce the acid taste of the product. Thus, different types of concentrated yoghurt are made in Turkey by the addition of various quantities of salt. Another traditional way of prolonging the keeping quality of concentrated yoghurt is employed in Lebanon, where the salted product is made into small balls about 2 cm in diameter and placed in the sun to dry. Afterwards the yoghurt balls (which are partially dried) are placed in either glazed earthenware pots or glass jars and covered with olive oil. The product is then referred to as winter yoghurt, that is, it is available when natural yoghurt is out of

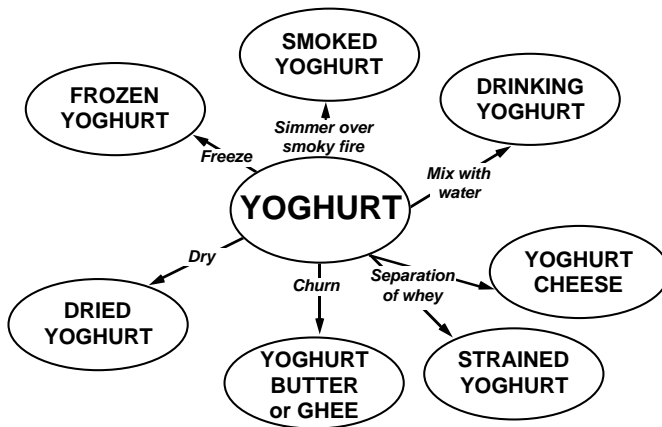


Fig. 1.2 Schematic illustration showing the different processes for the manufacture of yoghurt-related products

season and it has a storage life of up to 18 months; the product is spread easily on bread and consumed.

An alternative preservation process involves heating yoghurt for a few hours over low fires of a special type of wood; the end product is referred to as smoked yoghurt. This type of yoghurt is also preserved over the winter months by placing it in jars and covering it with either olive oil or tallow.

In some countries (Turkey, Lebanon, Syria, Iraq and Iran) the concentrated yoghurt is processed even further to produce a totally different product of almost indefinite keeping quality. This is a dried form of yoghurt; milk is processed into yoghurt in the traditional manner and wheat flour, semolina or parboiled wheat, known locally as burghol, is rubbed into it. The yoghurt–wheat mixture is shaped into small nuggets and placed in the sun to dry. This product is called kishk and it is sold either as nuggets or in a ground-up form as flour. Kishk (as a dish) is prepared by reconstituting the yoghurt–wheat mixture with water and then simmering the mix gently over a fire. The consistency of this product, which is normally consumed with bread, is similar to porridge.

The concentrated yoghurt can be also processed into a different product called chanklich. Here again the product is partially dried, but is then mixed with spices and herbs (presumably to assist in preservation). The mixture is then formed into balls, placed into glass jars and finally covered with olive oil. It is evident that many different products can be manufactured from yoghurt and Fig. 1.2 illustrates some examples; the relationship between these various products is discussed further in Chapter 5.

1.4 Patterns of consumption

As refrigeration became widespread, so interest in these traditional products declined, except among certain communities in the Middle East. In their place, a new generation of yoghurts emerged, with production typically centred on a large modern creamery, and success in the market place depending on the existence of a

Table 1.2 Per capita annual consumption (kg head⁻¹) of fermented milks in some selected countries

Country	1975 ^a			1980			1985			1990			1993		
	B ^b	Y ^b	O ^b	B	Y	O	B	Y	O	B	Y	O	B	Y	O
Australia	–	1.0		–	1.8	–	–	2.8	–	–	3.5	–	–	4.8	–
Austria	0.6	3.4	3.9	2.0	5.8	2.0	2.2	6.6	2.2	2.9	7.5	–	1.9	8.6	2.5
Belgium	6.7	5.1	–	2.8	4.9	–	2.3	6.0	0.06	1.9	6.5	1.2	2.3	5.7	3.9
Canada	4.4	0.7	–	0.6	1.7	–	0.6	2.5	–	0.5	3.2	–	0.4	3.1	–
Chile					1.4			2.5			3.9				
Czechoslovakia	0.9	1.3	1.7	3.1	1.7	2.5	3.9	2.5	3.1						
Denmark	23.1	5.9	7.1	9.8	9.1	7.8	8.4	8.0	7.5	6.9	7.8	6.9	5.6	8.3	6.8
Federal Germany	7.7	4.6	4.2	2.2	6.7	1.2	2.1	7.9	1.1	2.8 ^c	10.6 ^c	0.8 ^c	2.6 ^c	11.3 ^c	0.9 ^c
Finland	7.2	6.3	29.1	4.1	8.4	28.5	1.9	9.4	28.0	1.2	11.7	25.4	1.1	13.3	23.7
France	1.8	← 7.8 ^d →			← 9.3 ^d →			← 12.7 ^d →			← 16.4 ^d →			← 17.3 ^d →	
Iceland		1.7			5.7			6.2	14.1		9.9	14.7		9.8	16.1
India					3.7	–	18.8	4.0	–	23.1	4.7	–			
Ireland	12.6	1.0	–	5.7	2.0	–		← 3.4 ^d →		3.2	← 3.1 ^d →				
Israel		3.4	10.7		4.7	9.6		6.8	9.1						
Italy				–	1.3		–	1.6	1.3	–	2.6	1.4	–	← 5.0 ^f →	
Japan	–	0.8	1.7	–	1.0	1.4	–	2.9	5.0	–	3.9	3.9	–	4.8	3.7
Luxemburg	1.9	3.3	0.2		← 5.1 ^d →			← 6.8 ^d →		1.8	6.1				
Netherlands	10.5	14.2	–	9.5	17.8	–	8.5	18.1	–	10.7	21.8	–	9.0	20.7	–
Norway	–	1.2	7.9	–	2.2	7.9	–	3.1	10.9	–	4.3	10.6	–	6.3	
Poland		← 3.2 ^d →		1.3	0.1	0.6	0.9	0.4	0.6						
Spain		3.4			← 6.0 ^d →			5.5			8.0			← 9.8 ^d →	
Sweden	4.2	2.3	17.6	0.1	4.2	19.7	0.03	5.4	21.9	0.002	7.4	21.7		7.5	21.1
Switzerland	5.5	10.9	–	1.0	13.8	–	1.2	16.2	–	1.7	17.3	–	1.7	17.0	
UK	–	1.7	–	–	2.8	–	–	3.1	–	–	4.3	0.1		4.6	0.2
USA	9.0	0.9	–	1.9	1.2	–	2.0	1.8	–				1.4	2.1	
Former USSR	–	–	7.2	–	–	6.2	–	–	7.5						

^a Data for buttermilk also includes skimmed milk. ^b B,Y,O: buttermilk, yoghurt and other fermented milks, respectively. ^c Data includes German Democratic Republic. ^d Data represent yoghurt and other fermented milk products.

Dash (–) indicates product is not manufactured; blank space indicates data are not available.

Data compiled from IDF (1977, 1982, 1987, 1992, 1995).

network of retail outlets with storage facilities at $<7^{\circ}\text{C}$. Initially, production was confined to natural yoghurt and the market was limited, in large measure, to those who believed that yoghurt was beneficial to health. Gradually, however, attitudes towards yoghurt changed, and the advent of fruit yoghurts during the 1950s gave the product an entirely fresh image. Instead of being a speciality item for the health food market, it became a popular and inexpensive snack food or dessert. Production figures reflect the expanding market. In the U.K., for example, the value of yoghurt sold per annum in 1990 ran to around £400 million (sterling) (Barrantes *et al.*, 1994), and such figures are now commonplace around the world. Indeed total production is still rising, a trend confirmed by the data shown in Table 1.2.

It is evident from Table 1.2 that fermented milks, and in particular yoghurt, are widely consumed around the world and according to Kurmann (1984), the factors that can influence consumption are:

- availability of milk
- food habits
- level of income
- advertising
- range of fermented milks available in the market
- distribution system
- relation to consumption of other dairy products
- religion.

However, the consumption of buttermilk is not properly classified in most countries because: (a) traditional or natural buttermilk is the by-product of butter making from ripened or cultured cream, (b) cultured buttermilk is produced by the fermentation of skimmed milk with the addition of butter flakes, and (c) there is sweet buttermilk which is not fermented; the data for buttermilk shown in Table 1.2 have to be assessed in a cautious manner. Nevertheless, fermented milk products made with mesophilic lactic acid bacteria (see Fig. 1.1) are widely consumed in the Scandinavian countries, while the yeast–lactic fermented milks are popular in the former USSR, eastern European countries and Mongolia.

1.5 Methods of production and classification

The methods of production of yoghurt have, in essence, changed little over the years and although there have been some refinements, especially in relation to lactic acid bacteria, that bring about fermentation, the essential steps in the process are still the same, namely:

- Raising the level of total solids in the process milk to around 14–16 g 100 g^{-1} .
- Heating the milk, ideally by some method that allows the milk to be held at high temperature for a period of 5–30 min; the precise time will depend on the temperature selected.
- Inoculating the milk with a bacterial culture in which *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* are the dominant organisms.

- Incubating the inoculated milk, in bulk or retail units, under conditions that promote the formation of a smooth viscous coagulum and the desired aromatic flavour/aroma.
- Cooling and, if desired, further processing, e.g. the admixture of fruit and other ingredients, pasteurisation or concentration (see Chapter 5).
- Packaging for distribution to the consumer under chilled conditions.

At present there are many different types of yoghurt produced worldwide, and Tamime and Deeth (1980) have proposed a scheme of classification that separates all types of yoghurt into four categories based on the physical characteristic of the product. This approach is illustrated in Table 1.3. However, these products and in particular yoghurt are subdivided into different groupings based on the following aspects:

- Legal standards (i.e. existing or proposed) to classify the product on the basis of chemical composition or fat content (full, semi-skimmed/medium or skimmed/low fat).
- Physical nature of the product, i.e. set, stirred or fluid/drinking; the latter is considered stirred yoghurt of low viscosity.
- Flavours (plain/natural, fruit or flavoured; the latter two types are normally sweetened).
- Post-fermentation processing (vitamin addition or heat treatment).

Figure 1.3 illustrates a scheme for the classification of yoghurt based on the above-mentioned criteria.

The fact that all commercial processes share this common “core” has led to the word yoghurt being applied to a whole range of products, for example, dried yoghurt, frozen yoghurt and even pasteurised yoghurt. The inclusion of these varieties under the banner of yoghurt offends some people, because yoghurt *per se* must, by virtue of the process, contain an abundance of viable bacteria originating from the starter culture. However, popular usage appears to have determined that, as long as a carton is clearly labelled with information about the nature of the finishing process, for example, pasteurised yoghurt, the integrity of the basic product has not been compromised. Common sense would suggest that this view will prevail.

This approach also implies that yoghurt manufacture must always include a fermentation stage, that is a coagulum produced by the direct addition of lactic acid should never be designated as a yoghurt or even yoghurt-like, yet it is this very stage

Table 1.3 Proposed scheme for the classification of all yoghurt products

Category	Physical state	Yoghurt products
I	Liquid/viscous	Yoghurt
II	Semi-solid	Concentrated/strained
III	Solid	Frozen
IV	Powder	Dried

Adapted from Tamime and Deeth (1980), Robinson and Tamime (1990) and Tamime and Marshall (1997).

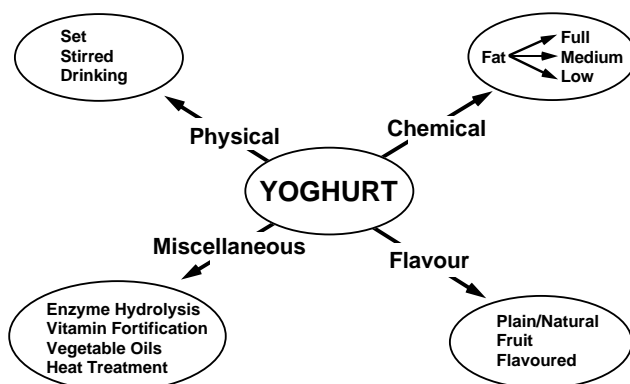


Fig. 1.3 Generalised scheme for the classification of yoghurt

that can, in commercial practice, prove extremely temperamental. Variations in milk composition, irregular behaviour of the starter organisms, faulty regulation of the incubation temperature, along with a number of other process variables, can all give rise to an end product that is deficient in respect of overall quality, and only a thorough understanding of the fermentation can provide an operative with the foresight to reduce the risk of product failure. It is with this background in mind that the relevant issues have been isolated for discussion, for although the different steps in production are interrelated, it is convenient to discuss them within the confines of an individual compartment. The following chapters are a reflection of this view.

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